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(54) IMPROVEMENTS IN OR RELATING TO ELECTRODES

(71) We, ENGLISH ELECTRIC VALVE COMPANY LIMITED, a British Company, of 106 Waterhouse Lane, Chelmsford, Essex CM1 2QU, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electrodes, and is specifically concerned with electrodes formed of the carbon known as pyrolytic graphite. Electrodes of this kind are used, for example, as control grids in high power, high frequency amplifier tubes, and the thickness of the electrode is very critical. It has proved difficult to machine such electrodes to accurately produce the required dimensions, and the present invention seeks to provide an improved electrode in which this difficulty is at least reduced.

According to this invention, an apertured electrode composed of pyrolytic carbon is provided with an apertured region in the shape of a hollow truncated cone, having a substantially uniform wall thickness.

The electrode is preferably provided with a relative massive base portion to support the apertured hollow truncated cone portion which is relatively thin and fragile.

Preferably, the taper is uniform along the length of the apertured region.

Preferably, the said substantially uniform wall thickness is achieved by grinding the outer surface of the hollow truncated cone portion whilst it is mounted on a close fitting rotatable mandrel.

Preferably again, the apertures are subsequently formed by producing perforations in the substantially uniform thickness wall by a shot abrasion process. It is convenient to produce a required array of perforations using a mask which fits closely over the ground wall surface with a matched taper.

Because the electrode is provided with walls having a taper over the region for which the wall thickness is critical, it can be much more accurately machined than can the conventional parallel-sided cylindrical electrode.

The invention is further described, by way of example, with reference to the drawing accompanying the Provisional Specification which illustrates in a section view an electrode in accordance with the present invention.

Referring to the drawing, the electrode consists of a conical portion 1, an end cap 2 and an annular base portion 3. The whole electrode is formed as a single continuous piece of pyrolytic graphite using known techniques. One such way of making the electrode is to use a solid truncated cone as a mandrel, and to pass a hot hydrocarbon gas over it, typically at a temperature of about 2000°C. The pyrolytic graphite is formed by deposition onto the mandrel and builds up in the form of a shell of molecularly oriented layers. The material exhibits a high thermal and electrical conductivity in a direction parallel to the layers, but only a low conduction normal to the layers. The mechanical properties are also anisotropic. The deposition is continued until the thickness of the shell is approximately .25 mm thick.

The pyrolytic carbon shell so formed, is removed from the mandrel as it cools,—the differential rates of contraction of the pyrolytic carbon and the mandrel cause the shell to be readily released. The shell is then mounted on a further conical mandrel, to enable portions of the side walls 1 to be ground down to a uniform and precisely determined thickness. Because both this mandrel and the pyrolytic graphite shell are tapered, and arranged to have the same angle of taper, the shell is gripped tightly by the mandrel allowing a grinding wheel to press firmly against its outer surface as both the shell and the grinding wheel are rotated.

The side walls of the electrode are perforated to allow electrons to pass through it when it is being used as a control grid, and the perforations can best be formed by a shot abrasion process in conjunction with

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a suitably shaped mask. In the drawing, the perforations are shown as diamond shaped apertures 4, but this is not essential, and any suitable shape can be employed.

Although in the drawing for the sake of clarity, the taper is shown as being fairly great, in practice a very shallow taper may be sufficient to ensure that the shell is tightly held for the grinding step. A taper of about 1° represents, probably, the lower limit, and to enhance the strength of the finished electrode a significantly greater taper is preferable. After grinding, the thickness of the ground wall of the shell may be as thin as 0.05 mm.

The use of a tapered electrode gives a number of advantages. As already mentioned, the taper enables the shell to be firmly held whilst it is ground down accurately to a uniform thickness, and the presence of the taper gives a much stronger electrode than would a parallel sided cylindrical electrode. Also the mask used for abrasively producing the perforations is easier to fit and remove, since it does not have to be an exact size.

When the electrode is used in a valve, in conjunction with other electrodes, an anode and a cathode, it may be desirable to also provide some or all of these with a similar taper, and it may be essential if the taper is fairly large relative to the spacing between an adjacent electrode. The inter-electrode spacing is important so far as the electrical performance of the valve is concerned, and if the tapered electrode is positioned close to the anode or cathode, these can also be tapered.

It will be apparent that the inter-electrode spacing is dependent on the relative axial positions of the electrodes. This may be a disadvantage for some applications, but it does provide a simple means of accurately and precisely adjusting the inter-electrode spacing for those applications where it is critical.

WHAT WE CLAIM IS:—

1. An apertured electrode composed of pyrolytic carbon having an apertured region in the shape of a hollow truncated cone and having a substantially uniform wall thickness over the apertured region.

2. An electrode as claimed in claim 1 and having a relative massive base portion to support the apertured hollow truncated cone portion which is relatively thin and fragile.

3. An electrode as claimed in claim 1 or 2 and wherein the taper of the truncated cone is uniform along the length of the apertured region.

4. An electrode as claimed in any of the preceding claims and wherein the said substantially uniform wall thickness is achieved by grinding the outer surface of the hollow truncated cone portion whilst it is mounted on a close fitting rotatable mandrel.

5. An electrode as claimed in claim 4 and wherein the apertures are subsequently formed by producing perforations in the substantially uniform thickness wall by a shot abrasion process.

6. An apertured electrode substantially as illustrated in and described with reference to the drawing accompanying the Provisional Specification.

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